Application No.09/341,339
Filed: August 30, 1999
TC Art Unit: 3723
Confirmation No.: 5010

AMENDMENTS TO THE SPECIFICATION

Beginning on page 1, line 7, please delete the first paragraph and replace the same with the following.

Field of the Invention

The present invention relates to a polishing method and apparatus for mirror processing of the internal surface of a long sized cylindrical workpiece such as a metallic tube, shape or the like, including an aluminum extrusion hollow shape with a cylindrical portion, using electrolytic integrated polishing technology, and to a long sized cylindrical workpiece such as an aluminum extrusion hollow shape polished by electrolytic integrated polishing according to the method.

Beginning on page 5, line 20, please delete the paragraphs from the end of page 5 to the last full paragraph on page 7, ending on line 24, and replace the same as follows.

Besides, since rotating metallic shapes having a variety of external shapes is virtually impossible, long sized cylindrical

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workpieces to which the above mentioned electrolytic integrated polishing apparatus can be applied are limited to cylinder pipes.

It is an object of the present invention, having been made considering the above mentioned problems with prior arts, to provide an electrolytic integrated polishing method and apparatus which enables high precision polishing of the internal surfaces of the cylindrical portions of metallic shapes having a variety of external shapes such as aluminum extrusion hollow shapes or the like, and to provide long sized cylindrical workpieces such as aluminum extrusion hollow shapes having internal surfaces of the cylindrical portions polished with a high precision.

Disclosure of the Invention

The method according to the present invention is an electrolytic integrated polishing method for polishing the internal surface of the cylindrical portion of a long sized cylindrical workpiece such as an aluminum extrusion hollow shape by integrating elution by electrolyte and abrasion by a grindstone attached to a tool electrode inserted into the cylindrical portion, characterized by disposing the long sized cylindrical workpiece ~~aluminum extrusion hollow shape~~ so that the axial center

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of its cylindrical portion is aligned with the vertical direction, inserting the tool electrode attached to the tip of a rotation shaft supported downward similarly along the vertical direction into the cylindrical portion, and rotating as well as relatively moving the tool electrode vertically.

Besides, the apparatus according to the present invention is an electrolytic integrated polishing apparatus for polishing the internal surface of the cylindrical portion of a long sized cylindrical workpiece such as an aluminum extrusion hollow shape by integrating elution by electrolyte and abrasion by a grindstone attached to a tool electrode inserted into the cylindrical portion, characterized by comprising a work supporting unit for disposing the long sized cylindrical workpiece ~~an aluminum extrusion hollow shape~~ so that the axial center of its cylindrical portion is aligned with the vertical direction, a rotation shaft supported downward along the vertical direction and inserted into the cylindrical portion of the above mentioned long sized cylindrical workpiece ~~aluminum extrusion hollow shape~~, the tool electrode attached to the tip of the rotation shaft, and a transportation unit for moving the above mentioned rotation shaft and/or the work supporting unit along the axial direction.

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In the present method and apparatus, because the rotation shaft is supported downward along the vertical direction and the tool electrode is attached to the tip thereof, influence of the weight of the tool electrode and the rotation shaft themselves is eliminated to suppress deflection of the tool electrode, which improves the precision of processing. Besides, the present method and apparatus can be similarly applied to a variety of metallic shapes such as an aluminum extrusion hollow shape having a variety of external shapes, because only the tool electrode is rotated without rotating the long sized cylindrical workpiece ~~aluminum extrusion hollow shape~~.

Here, the above mentioned transportation unit may be disposed at either one of or both sides of the rotation shaft and the work supporting unit. That is, any disposition will do if the long sized cylindrical workpiece ~~aluminum extrusion hollow shape~~ and the tool electrode move along the axial direction relatively to each other.

Beginning on page 8, line 12, please delete the first full paragraph ending on line 23, and replace the same as follows.

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Besides, when the above external tube is provided, it is preferable to wind a plastic tube spirally around the peripheral thereof and to enable pressurization inside the plastic tube. When the external tube is inserted, for example, into the cylindrical portion of a long sized cylindrical workpiece, such as an aluminum extrusion hollow ~~shape and~~ shape, and pressure is applied onto the plastic tube at the state, the plastic tube expands and is pressed against the internal surface of the cylindrical portion.

Beginning on page 9, line 8, please delete the first full paragraph, ending on line 15, and replace the same as follows.

Moreover, by the electrolytic integrating polishing method and apparatus, it becomes possible to perform finish polishing, without machining, of a long sized metallic shape such as an aluminum extrusion hollow shape, the length of the cylindrical portion of which is ten times as large as the diameter, or more, with a roundness of the internal surface of the cylindrical portion equal to or smaller than 10μm and a surface roughness Rmax

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along the axial and circular directions equal to or smaller than 1μm.

Beginning on page 10, line 8, please delete the paragraph ending on page 11, line 1, and replace the same as follows.

As shown in Figs. 1 and 2, the electrolytic integrated polishing apparatus includes a platform 1, a frame 2 disposed on the platform, an external tube 3 vertically disposed, a rotation shaft 4 vertically and free-rotatably disposed via a plurality of bearings (not shown) inside the external tube 3, a tool electrode 5 attached to the ~~top~~ tip of the rotation shaft 4 at the lower portion of the external tube 3, a plastic tube 6, inside of which can be pressurized by a mechanism (not shown), comprising a silicon tube or the like and being spirally wound around the peripheral of the external tube 3, a guide 7 attached to the frame 2, a sliding member 8 freely and vertically slidable along the guide 7, a supporting member 9 fixed to the sliding member 8 for supporting the upper end of the external tube 3, a bearing member 10 fixed to the sliding member 8 for supporting nearby the upper portion of the rotation shaft 4, a transportation motor 11 for sliding the sliding member 8 vertically along the guide 7 thus

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moving the external tube 3 and the rotation shaft 4 upward and downward, a motor 12 attached to the sliding member 8 for rotating the rotation shaft 4, and a fixed chuck 13 (positive pole energizing chuck) for fixing a long sized cylindrical workpiece, such as, for example, an aluminum extrusion hollow shape W.

Beginning on page 14, line 16, please delete the last paragraph, and replace the same as follows.

Firstly, the aluminum extrusion hollow shape W to be processed is grasped by the fixed chuck 13 and fixed on the free ring mechanism 19 via the seal packing 28, and the free ring mechanism 16 is fixed on the aluminum extrusion hollow shape W via the seal packing 27. Here, the axial center of the internal surfaces of the cylindrical portion of the aluminum extrusion hollow shape W, each of the free rings 23 to 26 and the ~~restricting~~ guide sleeve 17 must be aligned on the same axial line, and, at the same time, they must be aligned on the same axial line of the external tube 3, the rotation shaft 4 and the tool electrode 5. (see Fig. 1)

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Beginning on page 14, line 16, please delete the last paragraph, and replace the same as follows.

While the polishing process is being performed, the plastic tube 6 is pressurized and pressed against the internal surfaces of the cylindrical portion of the aluminum extrusion hollow shape W, the free rings 23 and 24, and the ~~restricting~~ guide sleeve 17, respectively preventing minute deflections of the external tube 3 caused by rapid rotation of the rotation shaft 4 and the tool electrode 5, which eventually prevents deflection of the tool electrode 5 in the cylindrical portion. By disposing the guide sleeve 17 with a constant length successively above the free ring mechanism 16, the plastic tube 6 can provide a contacting internal surface until the elastic grindstones 37 and 38 are completely withdrawn from the cylindrical portion of the aluminum extrusion hollow shape W and stopped rotating, which can prevent deflection of the external tube 3.

Beginning on page 18, line 23, please delete the paragraph from the end of page 18 to page 19, line 6, and replace the same as follows.

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Here, metallic tubes or shapes made from steel, stainless steel, aluminum, aluminum alloy or the like may be exemplified, although not limited to them, for the long sized cylindrical workpiece to which the method according to the present invention is applied. Besides, the length of the cylindrical portion is ten times as large as the diameter, or more. The long sized cylindrical workpiece ~~aluminum extrusion hollow shape~~ is finished to have a roundness of the internal surface of the cylindrical portion thereof equal to or smaller than 10μm and a surface roughness Rmax equal to or smaller than 1μm, by the electrolytic integrated polishing.

Beginning on page 20, line 1, please delete the remaining paragraphs in the description to page 21, line 2, and replace the same as follows.

(Example 2)

A 600 mm long stainless steel cold-finished tube was disposed in a vertical type electrolytic integrated polishing apparatus shown in Fig. 1 for polishing its internal surface (32 mm of finishing bore). Polishing was performed with the tool electrode having two-layered electrodes and elastic grindstones for coarse

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polishing and finishing, and under a condition that the electrolyte was sodium nitrate aqueous solution (20%), applied voltage was 8V, rotation speed of the tool electrode was 3.0 m, rising speed was 0.4m per minute.

As a result, surface roughness (Rmax) of the base tube, which was 10μm before polishing, became after finishing, 0.2μm with a grain size #1500 and 0.08μm with a grain size #6000, all of which provided an excellent mirror finishing.

Applicability to Industry

According to the present invention, polishing of the internal surface of the cylindrical portion of a long sized cylindrical workpiece ~~an aluminum extrusion hollow shape~~ with a high precision in terms of roundness and surface roughness becomes possible, without machining. Therefore, for example, a process, wherein a workpiece still in the form of a long sized material is polished and afterwards cut into pieces with a length of a fluid pressure cylinder, can be performed, improving the efficiency of the high-precision polishing and the productivity. Additionally, the present invention can be applied to high-precision polishing of the internal surfaces of the cylindrical portions of metallic

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shapes ~~aluminum extrusion hollow shapes~~ having a variety of external shapes.

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